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# AN ECONOMIC ANALYSIS OF *ZERO-TILLAGE* WHEAT PRODUCTION IN EASTERN UTTAR PRADESH, INDIA

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***ABSTRACT***

***Conservation agriculture saves the cost of irrigation, energy and protects the environment while leading to improved productivity on a sustainable basis. The present study was an attempt to analyze the farm-level impact of zero-tillage wheat production in Kaushambi district of Uttar Pradesh. Purposive random sampling is used for the selection of blocks, village and respondents for collecting primary data. Zero-tillage adopters and non-adopters were taken as a respondent in the cultivation of the wheat crop. Inputs cost and yield differences of zero-tillage adopters and non-adopters were used to analyze the economic benefits associated with zero-tillage and saving of diesel for land preparation and sowing of the wheat crop was used as environmental benefits of zero-tillage. A study revealed that per hectare, cost of cultivation was reduced by Rs. 7228 and yield were increased by 5.9 quintals under zero tillage as compared to conventional method of wheat cultivation. From the adoption of zero-tillage, per hectare diesel was saved by 28.4 liters and therefore, 73.9 kg carbon dioxide ($CO_2$) and 19.9 kg carbon were reduced. Among some constraints, important first four ranks were assigned to weed problem on farmers' field, poor soil quality, upland area and uncertainty of irrigation. A study suggested that the government should provide subsidy on the zero-tillage machine. It will enhance the availability of machine in the study area and it will also reduce the cost of hiring the zero-tillage machine. By adoption of zero-tillage for the wheat sowing be beneficial in terms of yield gain, cost saving, energy saving, and environment protection and reduction in the import of diesel which ultimate cut down the foreign exchange.***

***KEYWORDS: Zero-Tillage, Cost of Cultivation, Garrett Raking & RCT***

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## INTRODUCTION

The term Resource conservation technology (RCT) refers to the agronomic practice that enhances resource productivity or input-use efficiency such as zero/reduced tillage, laser leveling, bed and furrow configuration for planting crops, etc. (Kumar *et al.*, 2012). There are a number of available resource-conserving agricultural technologies that reduce soil erosion and improve resource conservation. They can be defined as a rational use of land resources, application of erosion control measures, and water conservation technologies, and adoption of appropriate cropping pattern to improve soil productivity and to prevent land degradation and thereby enhance livelihoods of the local communities (Grazhdani, 2013). Degradation of the natural resource-based resulting from inappropriate land and input use is widely documented as one of the root causes of the situation (Ali and Byerlee, 2000; Erenstein *et al.*, 2008), which has compelled many agricultural scientists and policymakers to look toward a more sustainable path of cereal production, viz. conservation agriculture (CA) and RCTs (Erenstein and Laxmi, 2008; Gupta and Sayre, 2007). While the CA technology ensemble is based on the principles of minimal soil disturbance, residue retention, rational crop rotation, and controlled traffic, RCTs cover all farming

practices/ technologies that facilitate the conservation and enhancement of resource use efficiency in farming (Erenstein, 2009; FAO, 2010; Gupta and Sayre, 2007; Harrington and Erenstein, 2005). These sustainable agriculture practices, which herald a paradigm shift in tillage and land preparation options, aid farmers in cost-saving and yield enhancement by shifting from conventional tillage wheat to minimal/zero tillage wheat, moving from puddled transplanted rice to zero tillage (ZT) direct seeding in rice, and engaging in other resource-saving practices (Hobbs, 2007). Most prominent among such CA-based RCTs in the cereal system of South Asia is the minimal/zero tillage of wheat (Erenstein and Laxmi, 2008; Gupta and Sayre, 2007; Laxmi *et al.,* 2007).

Research in India on zero-tillage wheat started in the 1970s but was soon abandoned due to technical constraints (Ekboir, 2002). However, with the involvement of the Consultative Group for International Agricultural Development in the South Asia region under the Rice-Wheat Consortium (RWC) program of the Indo-Gangetic Plains, zero-tillage technology gained momentum in the late 1990s in north-west Indian states. Here, after the initial spread, the area under the technology stabilized at 20–25 per cent (Erenstein, 2009). A tractor-drawn zero-tillage seed drill forms the machinery component of the technology, which allows the wheat seed to be sown directly into unploughed fields with a single pass of the tractor, often with simultaneous basal fertilizer application. Despite having a relatively short history of adoption, the technology is reported to have helped wheat farmers overcome the constraint of late sowing of the crop after harvesting late-maturing basmati rice and of the widespread incidence of the weed Phalaris minor (Mehla *et al.,* 2000; Erenstein and Laxmi, 2008).

The diffusion of the technology has accelerated in the early years of the $21^{st}$ century, particularly in the North-west Indo-Gangetic Plains of India, where the combined zero- and the reduced-tillage wheat area seems to have stabilized at between a fourth and a fifth of the wheat area. Several factors make it problematic to reliably measure zero-tillage adoption and impacts in the Indo-Gangetic Plains. Zero-tillage wheat allows for a drastic reduction in tillage intensity, with significant costs savings as well as potential wheat yield gains through the planting of the wheat crop at a better time (Erenstein, 2009).

## METHODOLOGY

### Study Area

The state of Uttar Pradesh has been divided into four parts on the basis of location as, Eastern Uttar Pradesh, Western Uttar Pradesh, Central Uttar Pradesh, and the southern part is called as Bundelkhand. Eastern Uttar Pradesh is the most populous part of Uttar Pradesh, where agriculture is the main source of livelihood for the rural community. Kaushambi district falls under the eastern plain agro-climatic zone of the Uttar Pradesh. A total land area of the district lies in between the holy rivers Ganga in North and Yamuna in South and comprises of alluvial soil group having sandy and sandy loam soil. Zero tillage, rotavator, and seed drill are mostly used as resource-conserving technology in the cultivation of wheat crop in the district. Objectives of the present study was (a) to compare the cost of cultivation for both zero-tillage adopters and non-adopters; (b) To estimate the economic and environmental benefit of zero-tillage; and (c) to identify the constraints associated with the adoption of zero-tillage in the study area.

### Data Collection

The present study was based on the primary data. Primary data were collected from the zero-tillage adopters and non-adopters using pre-tested schedule. The data were collected on the quantity and price of different inputs used for crop

production and crop outputs for zero-tillage adopter and non-adopters.

**Sampling Procedure**

Multi-stage purposive random sampling was used to select the district, blocks, villages, and respondents. Kaushambi district was purposively selected on the basis of highest adoption of zero-tillage in the Eastern plain agro- climatic zone of Uttar Pradesh. Out of eight blocks, two blocks viz., Newada and Muratganj were selected purposively on the basis of highest adoption and lowest adoption of zero-tillage, respectively. Karidpur Newada village from Newada block and Mohnapur village from Muratganj were selected purposively on the basis of availability of zero-tillage adopters and non-adopters. From each village, 10 zero-tillage adopters and 10 zero-tillage non-adopters were selected randomly. Thus, altogether, 40 respondents were finally selected from both villages.

**Analytical Tools**

For the calculation of cost of the cultivation, the cost concept developed by Commission for Agricultural Cost and Price (CACP) was used:

Cost $A_1$ = All cost of working capital + interest on working capital + Depreciation on implements and farm buildings

Cost $B_1$ = Cost $A_1$ + interest on value of owned fixed capital assets

Cost $C_1$ = Cost $B_1$ + imputed value of family labour

Cost $C_2$ = Cost $B_1$ + imputed value of family labour + rental value of owned land and rent paid for leased-in land

Cost $C_3$ = Cost $C_2$ + value of management inputs at 10 per cent of Cost $C_2$

The economic benefits of zero-tillage were worked out by estimating the differences between the cost of inputs and yield differences of zero-tillage adopters and non-adopters.

The environmental benefits realized by the adoption of zero-tillage was quantified and documented. Generally, these benefits were a reduction in carbon emission. To find out the carbon emission following methodology was adopted:

1 liter Diesel = 2.6 kg of $CO_2$ (Jat *et al*., 2006)

1 kg $CO_2$ = 0.27 kg of carbon (Paustian *et al*., 2006)

Garrett raking was used to rank the constraints associated with the zero-tillage adoption. The percentage position of each rank will be converted to scores by referring to tables given by Garret and Woodworth (1969). The score of all the factors is arranged in order of their ranks.

$$\text{Per cent position} = \frac{100 * (R_{ij} - 0.50)}{N_j}$$

Where, $R_{ij}$ is the rank given for $i^{th}$ item $j^{th}$ individual

$N_j$ is the number of items ranked by $j^{th}$ individuals.

## RESULTS AND DISCUSSIONS

The results of the present study are discussed under the following heads i.e. per hectare cost of cultivation, net income and cost of production of wheat crop under zero-tillage and conventional method, agronomic and economic benefits of zero-tillage, environmental benefits of zero-tillage, constraints associated with adoption of zero-tillage and condition for adoption of zero-tillage in the study area.

### Cost of Cultivation of the Wheat Crop

Inputs used for cultivation of wheat crop for zero-tillage adopters and non-adopters are presented in Table 1. The total cost of cultivation for zero-tillage adopters and non-adopters was estimated to be Rs.28956.68 and Rs.36185.08 respectively. It means zero-tillage non-adopters were spending more money (Rs.7228.40) on the different inputs of wheat production as compared to zero-tillage adopters. Per hectare, input costs were estimated to be Rs.23384.43 and Rs.29033.51 for zero-tillage adopters and non-adopters respectively. None of the sample farmers in the study area were using farmyard manure. Per hectare cost of irrigation water used by the sample farmers for irrigating wheat crop was found to be Rs.7006.74 and Rs. 7855.31 for zero-tillage adopters and non-adopters respectively in the study area. In the case of chemical fertilizer, zero-tillage farmers were spending a lower amount as compared to non-adopters. Per hectare cost incurred by zero-tillage adopters on wheat seed was lower (Rs. 3687.38) than the zero-tillage non-adopter i.e. Rs.4369.34. It was due to the reduction in the quantity of seed in the study area.

**Table 1: Cost of Cultivation of Wheat Crop**

| S.N. | Particulars | Zero-Tillage ADOPTER | | | Zero-Tillage Non-Adopter | | |
|---|---|---|---|---|---|---|---|
| | | Physical Unit | Amount (Rs.) | % to cost $C_3$ | Physical Unit | Amount (Rs.) | % to cost $C_3$ |
| 1. | Human labour | | | | | | |
| a. | Family labour | 3.61 | 722.00 | 2.49 | 8.56 | 1711.93 | 4.73 |
| b. | Hired labour | 3.96 | 791.00 | 2.73 | 2.49 | 497.13 | 1.37 |
| 2. | Machine labour | 2.21 | 995.63 | 3.44 | 9.32 | 4195.04 | 11.59 |
| 3. | Seed | 118.38 | 3687.38 | 12.73 | 145.40 | 4369.34 | 12.07 |
| 4. | Manure | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 5. | Fertilizer (Kg) | | | | | | |
| a. | Urea | 275.30 | 1927.10 | 6.66 | 291.38 | 2039.66 | 5.64 |
| b. | DAP | 137.55 | 3301.20 | 11.40 | 149.43 | 3586.21 | 9.91 |
| c. | MOP | 14.55 | 334.65 | 1.16 | 9.91 | 59.48 | 0.16 |
| d. | Zn | 0.67 | 16.64 | 0.06 | 2.56 | 20.59 | 0.06 |
| e. | Sulphur | 1.26 | 27.09 | 0.09 | 0.72 | 8.80 | 0.02 |
| 6. | Insecticides and Pesticides | 0.00 | 245.00 | 0.85 | 0.00 | 247.50 | 0.68 |
| 7. | Irrigation (Hrs) | 56.51 | 7006.74 | 24.20 | 64.13 | 7855.31 | 21.71 |
| 8. | Harvesting and Threshing | | 4330.00 | 14.95 | | 4442.53 | 12.28 |
| | **Sub-Total** | | **23384.43** | **80.76** | | **29033.51** | **80.24** |
| 9. | Interest on working capital @7%/Annum | | 818.46 | 2.83 | | 1016.17 | 2.81 |
| 10. | Total Working Capital | | *24202.89* | 83.58 | | *30049.68* | 83.04 |
| 11. | Rental value of own land | | 1700.75 | 5.87 | | 2002.22 | 5.53 |
| 12. | Rent paid for leased in land | | 420.62 | 1.45 | | 843.63 | 2.33 |
| 13. | Cost of Cultivation over | | | | | | |
| a. | Cost $A_1$ | | 23480.89 | 81.09 | | 28337.76 | 78.31 |
| b. | Cost $B_1$ | | 23480.89 | 81.09 | | 28337.76 | 78.31 |
| c. | Cost $C_1$ | | 25602.25 | 88.42 | | 31183.61 | 86.18 |

| Table 1: Contd., | | | | | | | |
|---|---|---|---|---|---|---|---|
| d. | Cost $C_2$ | | 26324.25 | 90.91 | | 32895.53 | 90.91 |
| e. | Cost $C_3$ | | 28956.68 | 100.00 | | 36185.08 | 100.00 |

**Income and Cost of Production of Wheat Crop**

The past researchers reported that after adoption of zero-tillage, the per hectare yield of wheat crop was increased (Kumar *et al.*, 2005; Laxmi *et al.*, 2007; Pal *et al.*, 2010; Singh *et al.*, 2011; Singh and Meena, 2013; Veettil and Krishna, 2013). After the adoption of zero-tillage, sample farmers in the study area were received a higher yield of wheat grain and by-products.

Per hectare yield of wheat main-product and by-product under zero-tillage was estimated to be 35.45 and 34.31 respectively, whereas in the case of non-adopters it was 29.50 and 34.20 quintals respectively (Table 2). The incremental yield benefit received by the zero-tillage adopters was estimated to be 5.95 and 0.11 quintal per hectare for wheat grain and by-product respectively over the zero-tillage non-adopters.

**Table 2: Income and Cost of Production of Wheat Crop**

| Particulars | Zero-Tillage Adopter | Zero-Tillage Non-Adopter |
|---|---|---|
| **Crop yield and Market price** | | |
| Main product (Qt/Ha) | 35.45 | 29.50 |
| By-product (Qt/Ha) | 34.31 | 34.20 |
| Market price of Main product (Rs./Qt) | 1320.00 | 1320.00 |
| Market price of By-product (Rs./Qt) | 270.00 | 270.00 |
| **Gross Income (Rs./Ha)** | **56051.10** | **48168.97** |
| Net Income Over | | |
| Cost $A_1$ | 32570.21 | 19831.21 |
| Cost $B_1$ | 32570.21 | 19831.21 |
| Cost $C_1$ | 30448.85 | 16985.36 |
| Cost $C_1$ | 29726.85 | 15273.44 |
| Cost $C_1$ | 27094.42 | 11983.88 |
| **Cost of Production (Rs./Qt)** | | |
| Cost $A_1$ | 662.46 | 960.70 |
| Cost $B_1$ | 662.46 | 960.70 |
| Cost $C_1$ | 722.31 | 1057.17 |
| Cost $C_1$ | 742.68 | 1115.21 |
| Cost $C_1$ | 816.95 | 1226.73 |
| **Output-Input Ratio Over** | | |
| Cost $A_1$ | 2.39 | 1.70 |
| Cost $B_1$ | 2.39 | 1.70 |
| Cost $C_1$ | 2.19 | 1.54 |
| Cost $C_1$ | 2.13 | 1.46 |
| Cost $C_1$ | 1.94 | 1.33 |

Due to higher wheat production received by the zero-tillage adopters were received more gross income and net income over various costs as compared to zero-tillage non-adopters. With respect to cost $C_3$, zero-tillage adopters obtained an incremental net benefit of Rs.15111.55 as compared to non-adopters. The cost of production of wheat was higher for zero-tillage non-adopters overall costs and highest in cost $C_3$ (Rs.1226.73). The input-output ratio shows the feasibility of the enterprise and results showed that wheat production was beneficial for both zero-tillage adopters and non-adopters. From the result, it could be seen that input-output ratio over cost $C_3$, zero-tillage adopters were got almost double as they invested. So, wheat production is more desirable for zero-tillage adopters over non-adopters.

## Agronomic and Economic Benefits of Zero-Tillage

The past researchers were reported that after the adoption of zero-tillage, a yield of wheat was increased in many parts of the country (Sinha and Singh, 2005; Laxmi *et al.*, 2007; Pal *et al.*, 2010; Singh *et al.*, 2011 and Veettil and Krishna, 2013). Per hectare agronomic and economic benefits of zero-tillage for the wheat crop is represented in Table 3. Per hectare, agronomic benefit due to the adoption of zero-tillage in the study area was estimated to be 5.95 and 0.11 for wheat grain and wheat by-product respectively. Per hectare, economic benefits of zero-tillage were due to increase in yield of the wheat crop over the zero-tillage non-adopters and reduction in the use of various inputs used for wheat production in the study area was estimated to be Rs.15095.37 (Table 3).

**Table 3: Agronomic and Economic Benefits of Zero-Tillage**

| S.N. | Particulars | Benefits |
|---|---|---|
| **1.** | **Agronomic Benefits** | |
| **a.** | Yield Main-Product Benefit (Qt/Ha) | 5.95 |
| **b.** | Yield By-product (Qt/Ha) | 0.11 |
| **2.** | **Economic Benefits** | |
| **a.** | Due to reduction in labour use (Rs./Ha) | 696.05 |
| **b.** | Due to reduction in machine labour use (Rs./Ha) | 3199.42 |
| **c.** | Due to reduction in seed use (Rs./Ha) | 681.96 |
| **d.** | Due to reduction in fertilizer use (Rs./Ha) | 108.05 |
| **e.** | Due to reduction in pesticide use (Rs./Ha) | 2.50 |
| **f.** | Due to reduction in irrigation use (Rs./Ha) | 848.57 |
| **g.** | Due to reduction in harvesting use (Rs./Ha) | 112.53 |
| **h.** | Due to yield benefits (Rs./Ha) | 7882.13 |
| **e.** | Due to diesel saving (@Rs.55/Lt) | 1564.16 |
| **3.** | **Total Economic Benefits (Rs./Ha)** | **15095.37** |

## Environment Benefits of Zero-Tillage

Zero-tillage adoption for wheat cultivation is beneficial in environment point of view also. Many researchers reported that after the adoption of zero-tillage, the diesel consumption for land preparation and sowing of the wheat crop was reduced in different regions of the country. Farmers reduced 61 liters per hectare diesel consumption in Indo-Gangetic Plains using zero tillage (Laxmi *et al.*, 2007). In Haryana, 29.1 liters and in Bihar, 24.3 liters of diesel were saved per hectare due to adopting of zero-tillage (Pal *et al.*, 2010) as compared to conventional method of wheat cultivation.

In Kaushambi district, per hectare, diesel consumption for land preparation and sowing of the wheat crop was estimated to be 8.85 and 37.29 liters for zero-tillage adopters and non-adopters sample farmers (Table 4). Per hectare, $CO_2$ emission due to the burning of diesel was estimated to be 23.01 and 96.95 kg for zero-tillage adopters and non-adopters respectively, whereas per hectare carbon emission was found to be 6.21 and 26.18 kg respectively. The carbon emission was reduced due to the adoption of zero-tillage in the study area was estimated to be 19.97 kg per hectare (Table 4).

**Table 4: Environment Benefits of Zero-Tillage**

| Particulars | Zero-Tillage | |
|---|---|---|
| | **Adopter** | **Non-Adopter** |
| Diesel consumption (Lt/Ha) | 8.85 | 37.29 |
| $CO_2$ emission (Kg/Ha) | 23.01 | 96.95 |
| Carbon emission (Kg/ Ha) | 6.21 | 26.18 |
| Reduction in carbon emission (Kg/Ha) | 19.97 | |

Besides the reduction of carbon emission, zero-tillage also helps in the reduction of irrigation water use. Sample farmers of the study area were using groundwater to irrigate their wheat crop. Total water used for irrigating wheat crop by zero-tillage adopters and non-adopters were estimated to be 1747.17 and 1982.75 $m^3$ per hectare respectively. After adoption of zero-tillage, sample farmers were using less groundwater for irrigating their wheat crop. Reduction in irrigation water was estimated to be 235.58 $m^3$ per hectare which leads to a positive impact on the groundwater availability for different uses.

**Constraints Associated with RCT Adopters**

Garrett score is used to ranking fifteen constraints associated with zero-tillage adoption in the study area and it was presented in Table 5. Out of several constraints in adoption of zero-tillage in the stud area, most important was non-availability of the zero-tillage machine on time and non-availability of the zero-tillage machine on hire basis and rank was first and second respectively. Other constraints associated with adoption of zero-tillage in the study area was weed problem in the agricultural field, not sure about the profit after the adoption of zero-tillage, farmers were not sure about the technology, custom hiring of the zero-tillage machine is high, farmers do not own zero-tillage machine, etc. Past researchers also reported that major technical constraints associated with zero-tillage adoption as reported by Singh *et al.* (2007) and Kumar *et al.* (2005).

**Table 5: Constraints Associated with RCT Adopters**

| S.N. | Reasons for Non-adoption of RCTs | Garrett Score | Rank |
|---|---|---|---|
| 1 | Non-availability of zero-tillage machine on time | 77.25 | I |
| 2 | Non-availability of zero-tillage machine on hire basis | 66.80 | II |
| 3 | Weed problem in agricultural field | 65.70 | III |
| 4 | Not sure of profit | 61.90 | IV |
| 5 | Not sure about technology | 61.70 | V |
| 6 | Custom hiring of zero-tillage machine is high | 59.55 | VI |
| 7 | Does not own zero-tillage machine | 59.25 | VII |
| 8 | High cost of zero-tillage machine | 55.20 | VIII |
| 9 | Uncertainty of irrigation | 48.65 | IX |
| 10 | Labour issues | 38.45 | X |
| 11 | Poor soil quality | 35.90 | XI |
| 12 | Less yield under zero-tillage | 34.15 | XII |
| 13 | Lack of financial support | 29.40 | XIII |
| 14 | Upland field | 29.15 | XIV |
| 15 | Credit unavailability | 26.95 | XV |

**Conditions for Adoption of Zero-Tillage**

The conditions for the adoption of zero-tillage in the study area in the future are presented in Table 6. The most important condition for adoption of zero-tillage by the sample farmers in the study area was a cost of custom hiring of the machine is low. During the field, survey farmers were told that if the cost of hiring zero-tillage machine will reduce than they can adopt it. The second rank for a condition for adoption of zero-tillage was irrigation water availability. The third and fourth important factors for adoption of zero-tillage in the study area was non-availability of the zero-tillage machine on subsidy and if convinced of yield benefit. The least important condition for adoption of zero-tillage was better repaired services of zero-tillage machine and availability of skilled labor for operating the zero-tillage machine.

**Table 6: Condition for Adoption of Zero-Tillage**

| S.N. | Condition for Adoption of RCTs | Garrett Score | Rank |
|---|---|---|---|
| 1 | If custom hiring rate is low | 72.05 | I |
| 2 | Irrigation water availability | 66.25 | II |
| 3 | If ZT is available on subsidy | 58.60 | III |
| 4 | If convinced of yield benefit | 55.05 | IV |
| 5 | More observation on other field | 43.70 | V |
| 6 | If better repair service is available | 28.00 | VI |
| 7 | Non-availability of skilled labour | 27.70 | VII |

## CONCLUSIONS AND POLICY IMPLICATIONS

Farm-level impact of zero-tillage in Kaushambi district of Uttar Pradesh clearly indicated the superiority of Zero-tillage over conventional practices in terms of cost of cultivation, economic and environmental benefits. In order to enhance the productivity, profitability, and sustainability in wheat production, the tillage technologies known as zero tillage was developed. Zero-tillage adopters saved more machine hours in ploughing, harrowing and leveling as compare to non-adopters. Similarly, the cost of cultivation of wheat crop was lower in case of zero-tillage adopters as compared to non-adopters. By adopting the zero tillage technology farmers were obtained more yield and consequently higher revenue as compared to non-adopters. Higher agronomic and economic benefits were reported by practicing zero tillage technology as compared to the conventional method. By using the zero-tillage machine for wheat sowing, diesel consumption was saved and accordance to that carbon emission was reduced in large scale. Non-availability of zero tillage machines on time of sowing of wheat was the main constraint faced by farmers in the study area. Therefore, the government should provide subsidy on the purchase of the zero-tillage machine, which helps to augment in the availability of machine in the study area. It will also help in reduction in the cost of the zero-tillage machine on hiring basis and also available machine on time on hire basis.

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